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Heavy Metal Compositions in Gaborone Industrial Effluent

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Abstract: This study assessed the compositions of five heavy metals in Gaborone Industrial effluent from five industrial premises; a brewery, pharmaceutical company, paints and chemical industry (commercial photography studios and a soap manufacturing company).The heavy metals monitored were Lead (Pb), Cadmium (Cd), Iron (Fe), Nickel (Ni) and Zinc (Zn). All the industries discharged during the study period a certain amount of Nickel although in very minute concentrations in relation to the Gaborone City Council Sewer guidelines. Only the Photographic companies discharged Fe, 669.5 μg L^{-1} and none of the industries discharged Zn, Cd and Pb. Also, the Secondary Settling Tank (SST) effluent and dry sludge from the Gaborone city council wastewater treatment plant contained some amount of Ni, Zn, Pb and Fe. Potential discharge sources exist other than the five industries monitored for the discharge of Fe, Pb and Zn into the Gaborone city council sewers and these could be the educational facilities, testing laboratories and yet to be covered industries as well as the City council laboratory itself .

Key words: Heavy metals, effluent, cadmium, lead, zinc, nickel, iron

INTRODUCTION

Very few manufacturing industries exist in Gaborone. Of these, there are about five which are directly involved in manufacturing activities. These can be categorised generally as, brewery, abbatoirs, pharmaceutical/paint and chemicals industries. In an attempt to monitor and enforce the Gaborone City council sewer ordinance, industrial effluent discharge quality is monitored once every month for all the currently registered industries in Gaborone. Emongor *et al.*[1] had indicated industrial effluent as a potential source of Lead (Pb) pollution in Gaborone. Kealotswe *et al.*[2] indicated various levels of heavy metals in the sludge produced as well as in the effluent at the wastewater treatment works in Gaborone.

Heavy metals are known to cause deleterious effects on man as a result of diseases such as cancer. In extreme cases, they can destabilise the terrestrial as well as the aquatic environment through the contamination or pollution of the food chain and poisoning of potable water sources[3]. Some are however in minute concentrations are needed for healthy plant growth, e.g, Zn and Fe[4].

The objective of this study was to ascertain whether industrial effluent discharges are the possible sources of some selected heavy metals in the sludge and the final effluent water discharged at the Gaborone city council wastewater treatment plant. Cadmium (Cd), Lead (Pb), Zinc (Zn), Nickel (Ni) and Iron (Fe) were studied.

MATERIALS AND METHODS

Effluent samples were collected in 1000 mL polyethylene bottles during peak production hours at five industrial premises and acidified with 2 mL of concentrated HNO_3. Samples were prepared and analysed in accordance with

ISO 8288-1986 (E) methods[5] using Shimadzu Atomic Absorption Spectrophotometer 6650.

RESULTS AND DISCUSSION

Results show that non of the industries studied discharged Pb, Cd and Zn. However, all the industries were discharging Ni with the Paints industry discharging most, 92.5 μg L^{-1}. This was followed by photography, pharmaceutical, brewery and soap industries with, 87.5, 85.9, 72.7 and 66.7 μg L^{-1}, respectively. The composition of Ni in the Gaborone wastewater treatment plant sludge and the Secondary Settling Tank (SST) effluent were respectively, 233.8 μg kg^{-1} and 5.6 μg L^{-1}, respectively (Table 1). The higher composition of the metal in the sludge than the secondary effluent was in line with Toumi *et al.*[6]. This trend was same for all the heavy metals studied except Cd. Ni is used in electroplating of

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Table 1: Heavy metal compositions in gaborone industrial effluent

	Heavy metal composition in effluent				
Type of industry	Ni (μg L^{-1})	Fe (μg L^{-1})	Zn (μg L^{-1})	Cd (μg L^{-1})	Pb (mg L^{-1})
Brewery	72.7	0.0	0.0	0	0.0
Paints	92.5	0.0	0.0	0	0.0
Pharmaceutical	85.9	0.0	0.0	0	0.0
Soap	66.7	0.0	0.0	0	0.0
Phytography	87.5	669.5	0.0	0	0.0
Typical gaborone sludge	>233.8	>1443.6	>427.9	0	>125.5
Typical gaborone secondary effluent	5.6	5.2	0.0	0	0.0
Gaborone city council sewer discharge guideline	20.0 mg L^{-1}	20.0 mg L^{-1}	20.0 mg L^{-1}	5.0 mg L^{-1}	5.0 mg L^{-1}

Sludge value: μg/kg, 0-means no detectable analyte

nuts and bolts for holding and tightening machine joints. Rinse waters from these operations constitute the major avenues by which salts of the metal gain access to the environment. It has low toxicity in humans, however evidence exits that inhaled Ni may be carcinogenic[7]. The credible sources of Ni might be machine parts which have been coated with Ni and are therefore leaking the metal into the effluents. All the industries under study use equipment parts containing elements of Ni. The trend detected could be associated with frequency of production activity and hence tear and wear of Ni parts degree.

Only the Photography houses discharged Fe during the study period. An average of 669.5 μg L^{-1} Fe was discharged. Fe is used in photography during picture development when ferric chloride and potassium ferricyanide are used. The level of Fe in the Wastewater Treatment Plant dry sludge and the final effluent were 1443.6 μg kg^{-1} and 5.2 μg L^{-1}, respectively. Fe is a macro element needed for plant growth. In excess, it becomes a nuisance as the oxidised coatings in containers may be a health hazard. None of the industries discharging Ni and Fe exceeded the Gaborone City Council sewer guidelines limits of 20 mg L^{-1} for both Ni and Fe (Table 1).However, the presence of Ni, Fe, Zn and Pb in the treatment plant sludge or final effluent indicates that there are sources of Zn and Pb discharge in Gaborone and these sources might be educational facilities such as the University of Botswana chemical laboratories, Secondary schools and other testing laboratories including the treatment plant laboratory itself as a result of usage of commercially prepared standards or preparations as standards for analytical purposes which are discharged into the sewer after tests are performed. Fe could possibly also come from slaughter houses or abattoirs in the Gaborone municipality from blood from slaughtered animals. All these potential discharge points must be identified and monitored.

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